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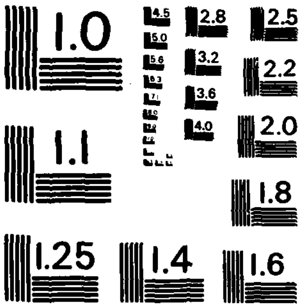
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Structures Technical Memorandum 345

RESONANCE TESTS ON THE TAIL OF A CT4 AIRCRAFT

A. GOLDMAN

Approved for Public Release

SEPTEMBER, 1982

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Structures Technical Memorandum 345

RESONANCE TESTS ON THE TAIL OF A CT4 AIRCRAFT

by

A. GOLDMAN

SUMMARY

A resonance test has been carried out on the tail section of a CT4 aircraft. Natural modes and frequencies of the tailplane were measured and these results are presented.

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CONTENTS

1. INTRODUCTION

These resonance tests on the tailplane of a CT4 aircraft were conducted in order to provide data for a load calculation programme being undertaken by an A.R.L. fatigue group.

An aircraft, registration number A19-031, was made available for testing at A.R.L. The period of availability was limited and all tests had to be set up and completed within five working days.

2. TEST PROCEDURE

In order to obtain good separation between the rigid body mode frequencies and the airframe mode frequencies, the undercarriage tyres were partially deflated. The rigid body mode frequencies were not measured, but a physical appraisal suggested that they were low enough to be well separated from the lowest probable tailplane frequency.

The tailplane was marked out with measuring stations as shown in Fig. 1. Four electromagnetic shakers were attached to the leading and trailing edge tips, and accelerometers were placed above the shaker attachment points. Using an oscillator, four amplifiers, a four-channel oscilloscope, and a transfer function analyser, the modes were tuned and measured generally as described in Ref. 1.

On completion of the modal measurements an attempt was made to measure the effect that the vibrators, attached to the structure, had on the frequencies of the modes measured. Accelerometers used in the tuning process were attached to the structure at the leading edge of the tailplane and the trailing edge of the elevator. These were connected, via amplifiers, to a FFT spectrum analyser. An impulse was applied to the structure and the response captured and analysed on the spectrum analyser. This was repeated with the vibrators disconnected from the structure. No measurement was made of the force level of the various inputs. The spectra obtained in these tests are presented in Figs. 7 to 10.

3. RESULTS

Table 1 sets out the five modes of vibration measured. These are as follows:-

14.9 hertz

This is elevator rotation about its hinges, and is illustrated in Fig. 2 which shows some slight tailplane bending. This mode was well isolated with a modal isolation parameter of 0.07.

21.92 hertz

This is the fundamental bending mode of the tailplane and elevator, illustrated in Fig. 3, and having a modal isolation parameter of 0.065.

30.94 hertz

Antisymmetric torsion of the elevator is predominant with some antisymmetric tailplane bending. This mode is illustrated in Fig. 4. Modal purity is not very good.

46.19 hertz

This is an antisymmetric bending mode of the elevator with the tailplane showing an antisymmetric bending mode in anti-phase to the elevator. The appearance of torsion at the tips of the elevator is caused by the restraining action of the pivot at that point. This mode is illustrated in Fig. 5.

69.10 hertz

At this frequency the elevator is in a torsion mode having nodes at the three restraining points, and the tailplane is in an antisymmetric bending mode. This mode is illustrated in Fig. 6. The modal isolation parameter is high, possibly due to local panel vibrations being excited at this frequency.

Modal isolation parameters were obtained by summing the components of acceleration measured in phase with the force input and dividing that sum by the sum of the components of acceleration measured in quadrature with the force input. A pure mode would have no in-phase components. Parameters less than 0.1 are considered good and less than 0.3 are acceptable. The vector response plots show all the measurements taken at each frequency. For a pure mode, these would all lie along the 90-270 degree line.

On the figures showing mode shapes, the points plotted are the quadrature components of measured acceleration. All measured points are plotted but curves have only been drawn through the leading and trailing edge points for clarity.

It should be noted that the scale used for plotting of any particular mode shape was selected to demonstrate the mode shape and not the actual amplitude of the vibration.

Damping in each mode was not measured, but an indication may be gained from the sharpness of the peaks on the spectra presented in Figs. 7 to 10. However, no attempt should be made to take quantitative measurements of damping from these spectra as the height of the peak could be affected by the frequency spacing between adjacent points, and the variations in applied force to the structures.

The changes in frequency of the various modes, due to attachment of vibrators, can be seen in Figs. 7 to 10. The vibrators used generally have natural frequencies around 25 hertz, and at frequencies below this, the effect of the vibrator is to raise the frequency, and at frequencies above, the effect of the vibrator is to lower the frequency. It can be seen that the lower frequency has changed from approximately 10.5 hertz to 12 hertz and the higher frequency has changed from 47.5 hertz to 46.5 hertz. The large variation between the frequency of elevator rotation measured in response to an impulse and that measured in response to steady state multi-point excitation may be due to backlash in the control circuit mechanism causing non-linearities in the structure. The small amplitude of displacement with an impulse may well keep the motion within the lower stiffness of the backlash region whereas the steady-state sinusoidal excitation would introduce a larger displacement and go beyond the backlash limits into the higher stiffness region of control circuit extension.

It should be noted when examining Figs. 7 to 10 that the vertical scale on Figs. 7 and 9 is 0.04 volts full scale, and on Figs. 8 and 10 it is 0.08 volts full scale. The change in the peak at 31 hertz caused by disconnecting the vibrators is not fully understood, and the lack of time did not permit further investigation. It may well be the result of the impulse being applied in a different manner such that this particular mode, antisymmetric torsion, was not sufficiently excited in the case without vibrators attached.

4. CONCLUSIONS

The resonant frequencies of the tailplane and elevator of the CT4 aircraft have been measured, in the frequency range up to 80 hertz, and the effects on these frequencies of the vibrators used has been noted as slight.

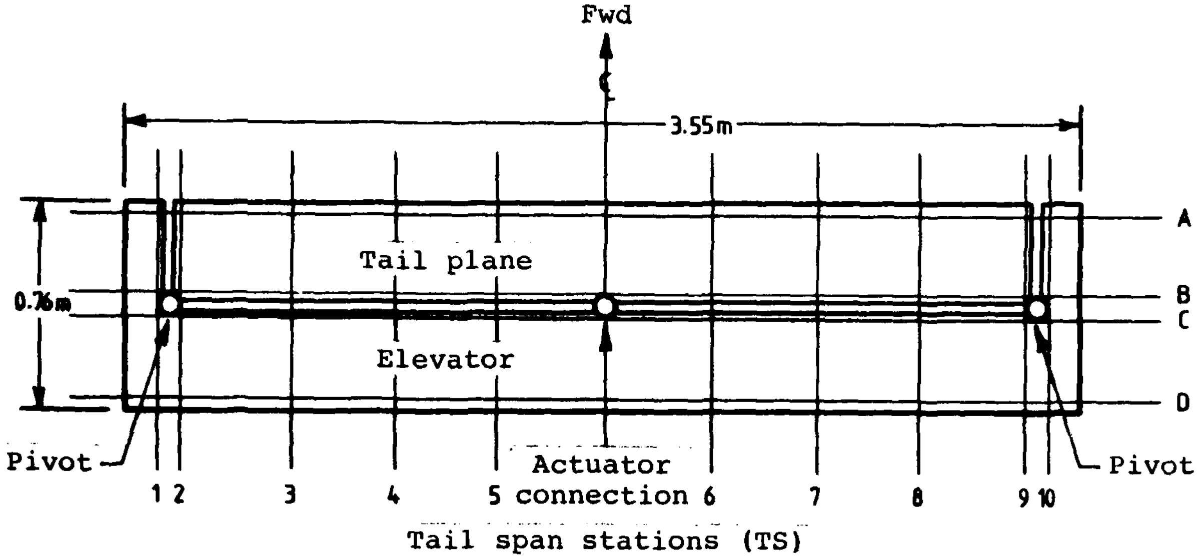
REFERENCES

1.	Goldman, A. and Quinn, B.	Resonance Tests on a Piper PA-32R Tailplane. Struct. Tech. Memo. 328, April 1981

TABLE 1

SUMMARY OF VIBRATION MODES AND FREQUENCIES

Frequency	Description	Fig.	Modal Isolation Parameter
14.90 Hz	Elevator rotation	2	0.07
21.92 Hz	Fundamental tailplane bending	3	0.065
30.94 Hz	Antisymmetric torsion of elevator	4	0.132
46.19 Hz	Antisymmetric bending of elevator	5	0.131
69.10 Hz	Three node antisymmetric torsion of elevator	6	0.223



On the following figures 2 to 7

+	Indicates motion perpendicular to points along gridline	A
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FIG. 1 MEASURING STATIONS AND OVERALL DIMENSIONS

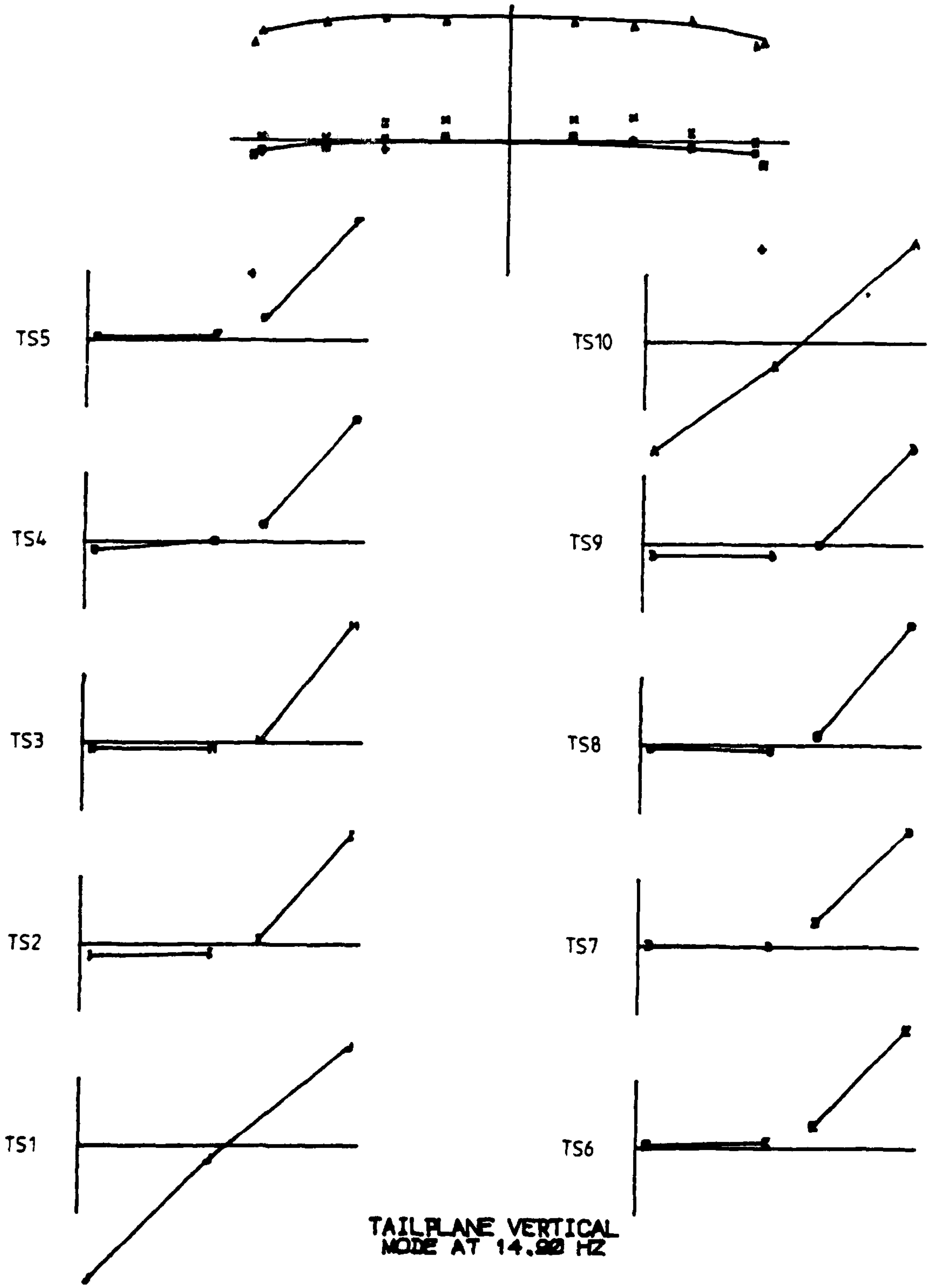


FIG. 2(a) VIBRATION MODE AT 14.90 Hz

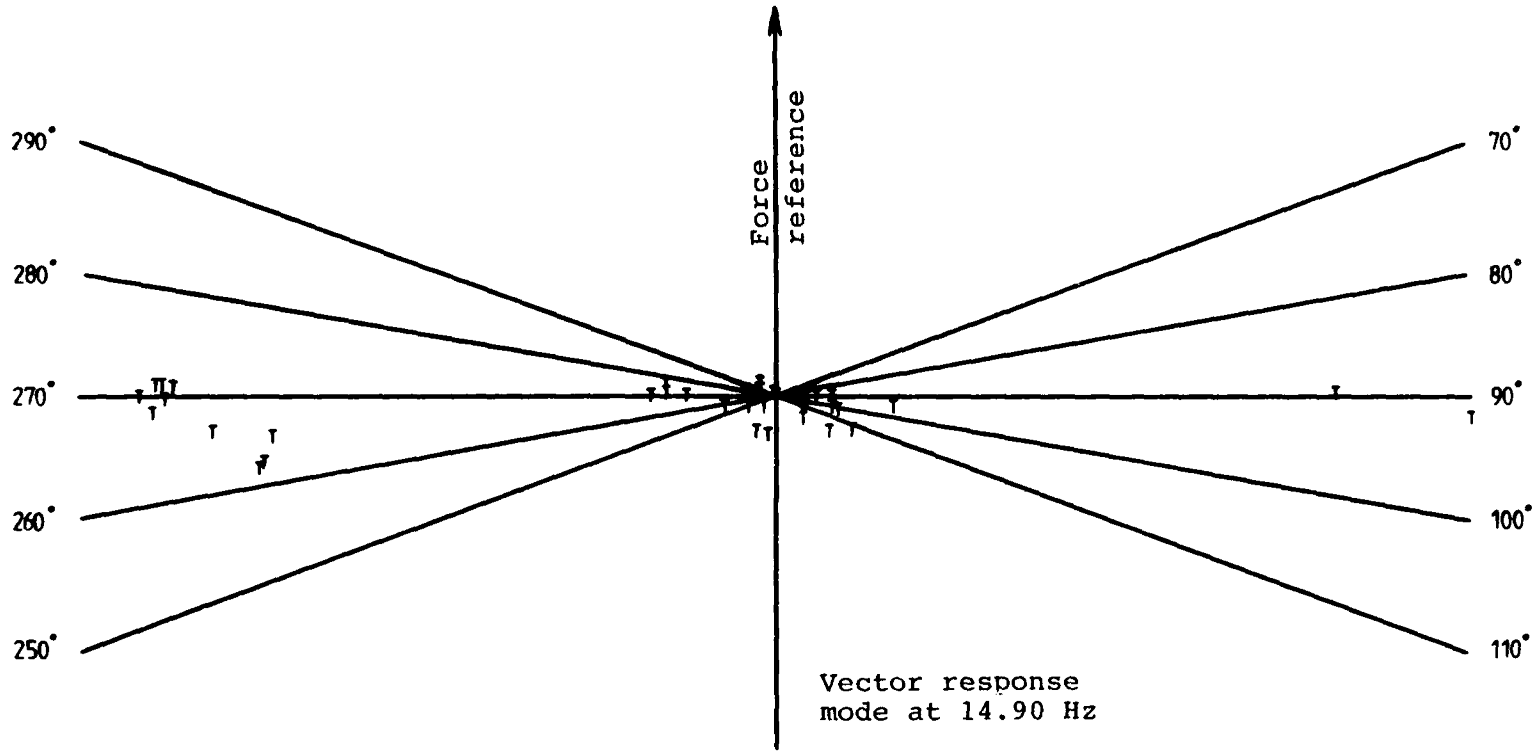


FIG. 2(b) VECTOR RESPONSE OF MODE AT 14.9 Hz

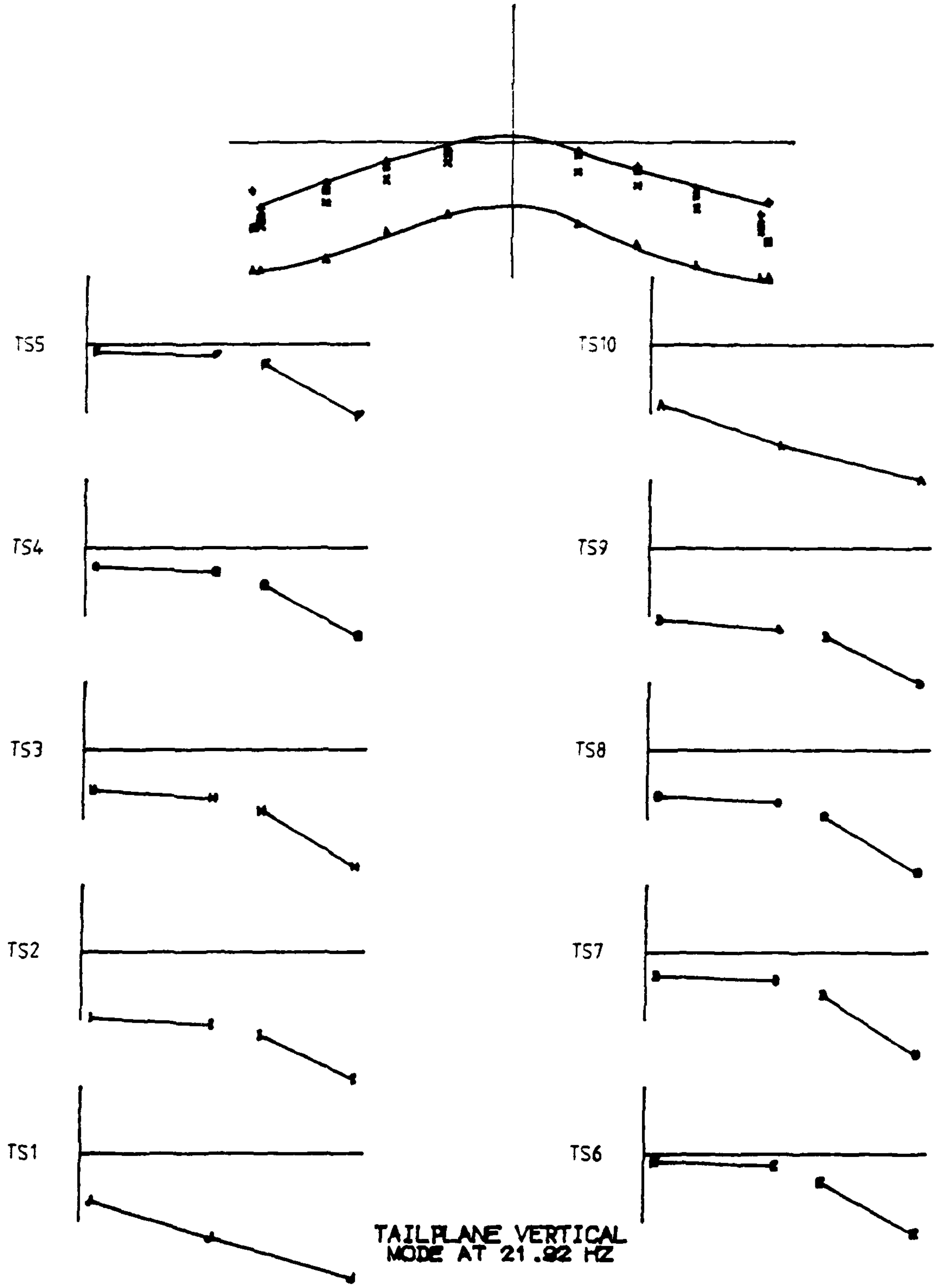


FIG. 3(a) VIBRATION MODE AT 21.92 Hz

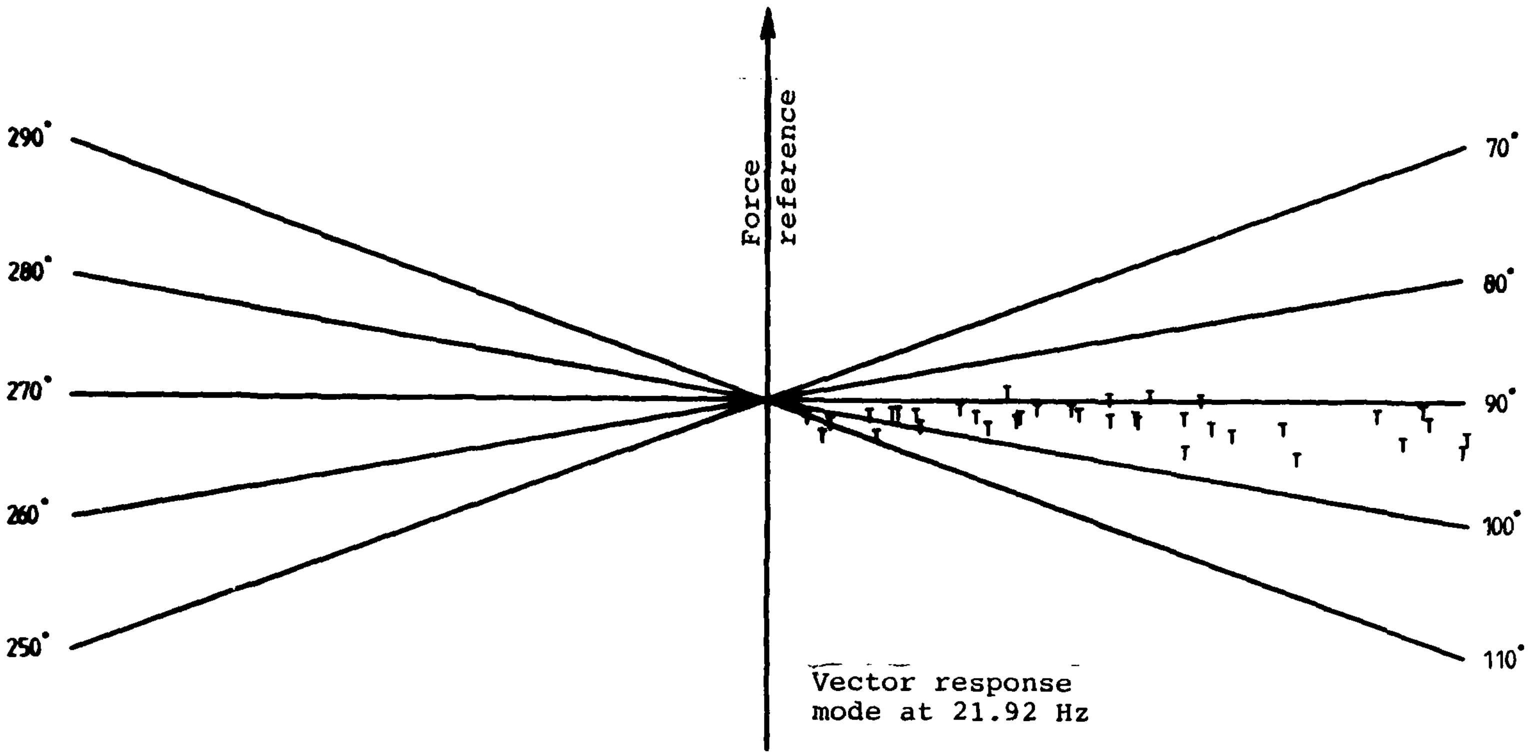


FIG. 3(b) VECTOR RESPONSE OF MODE AT 21.92 Hz

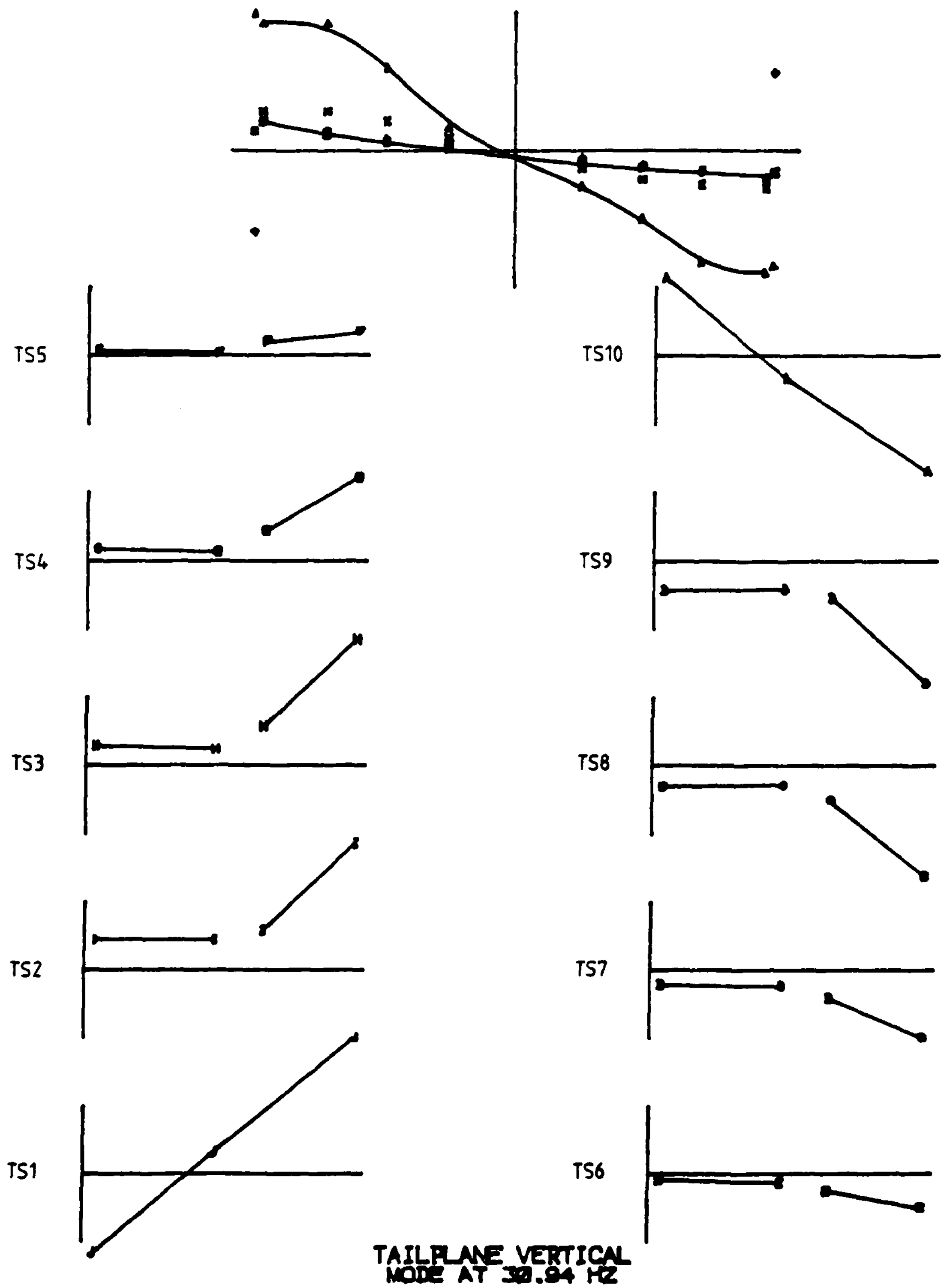


FIG. 4(a) VIBRATION MODE AT 30.94 Hz

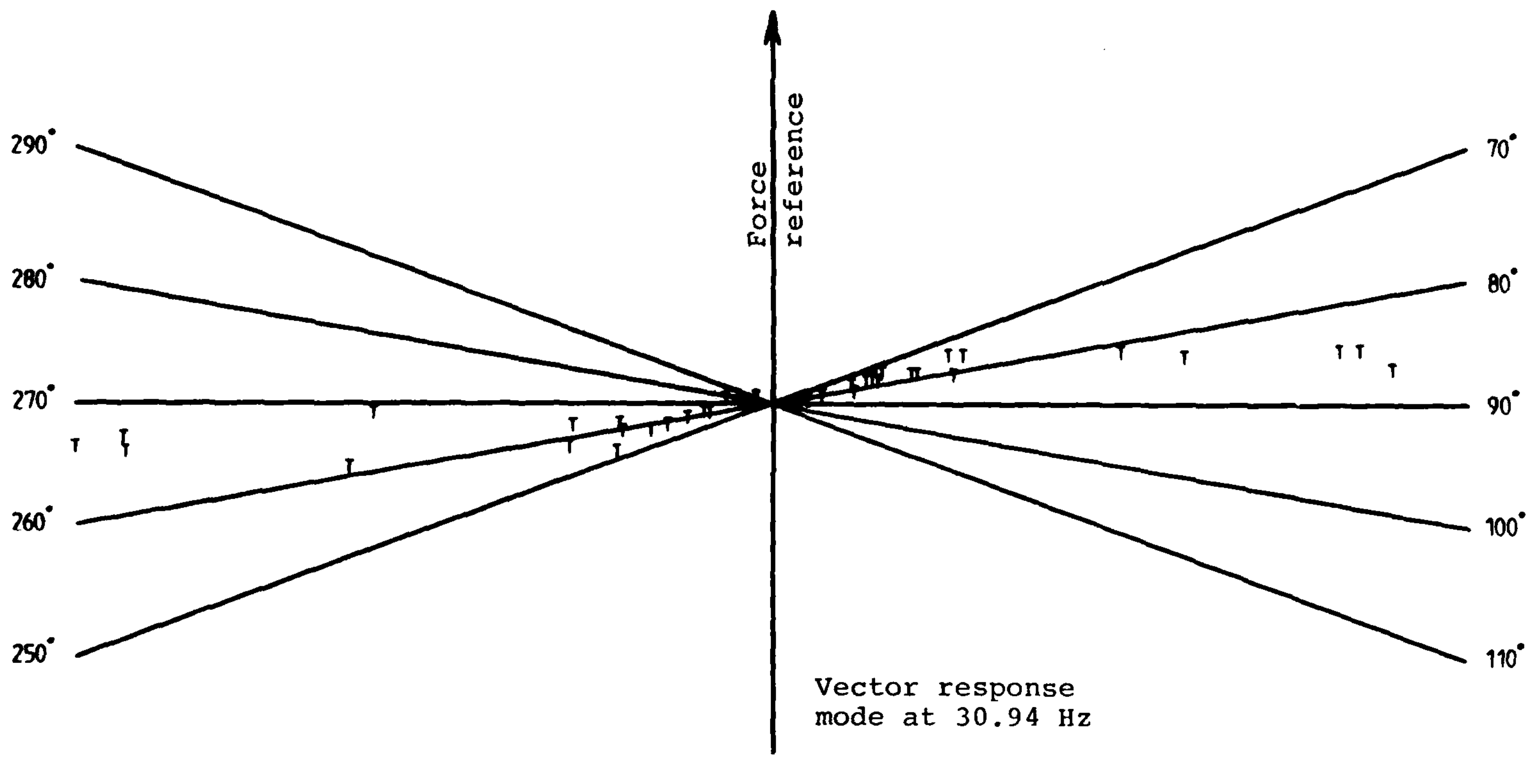


FIG. 4(b) VECTOR RESPONSE OF MODE AT 30.94 Hz

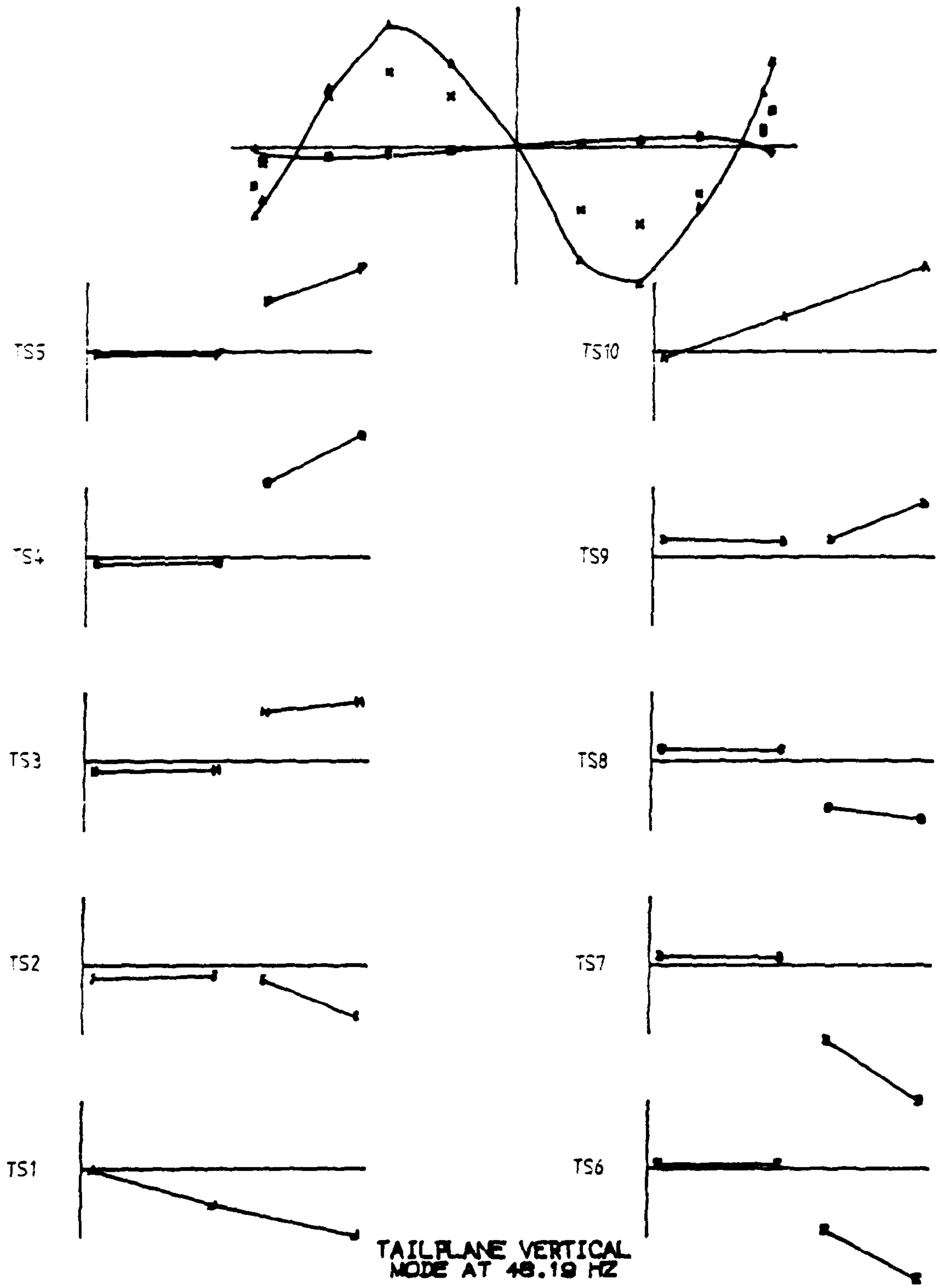


FIG. 5(a) VIBRATION MODE AT 46.19 Hz

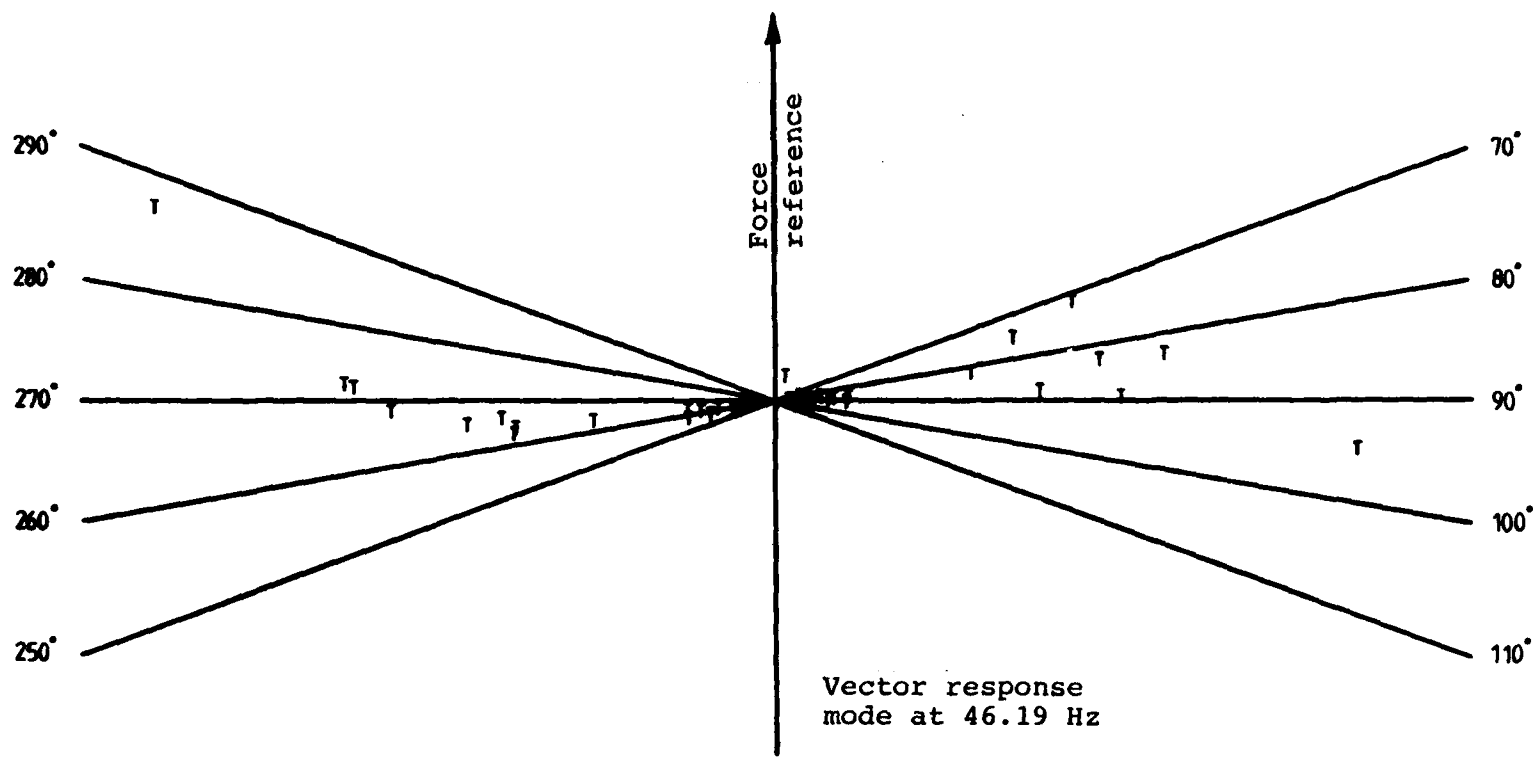


FIG. 5(b) VECTOR RESPONSE OF MODE AT 46.19 Hz

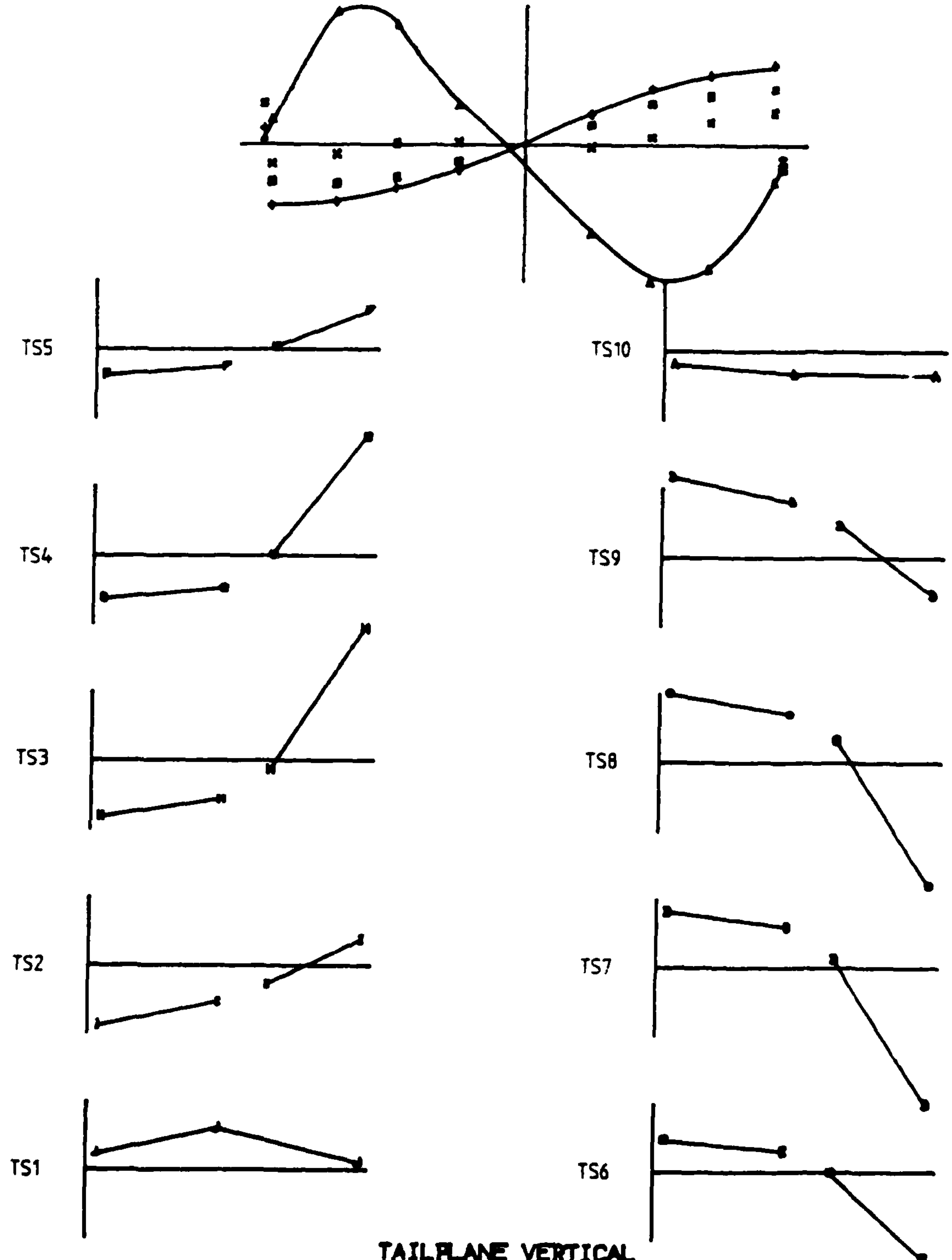


FIG. 6(a) VIBRATION MODE AT 69.10 Hz

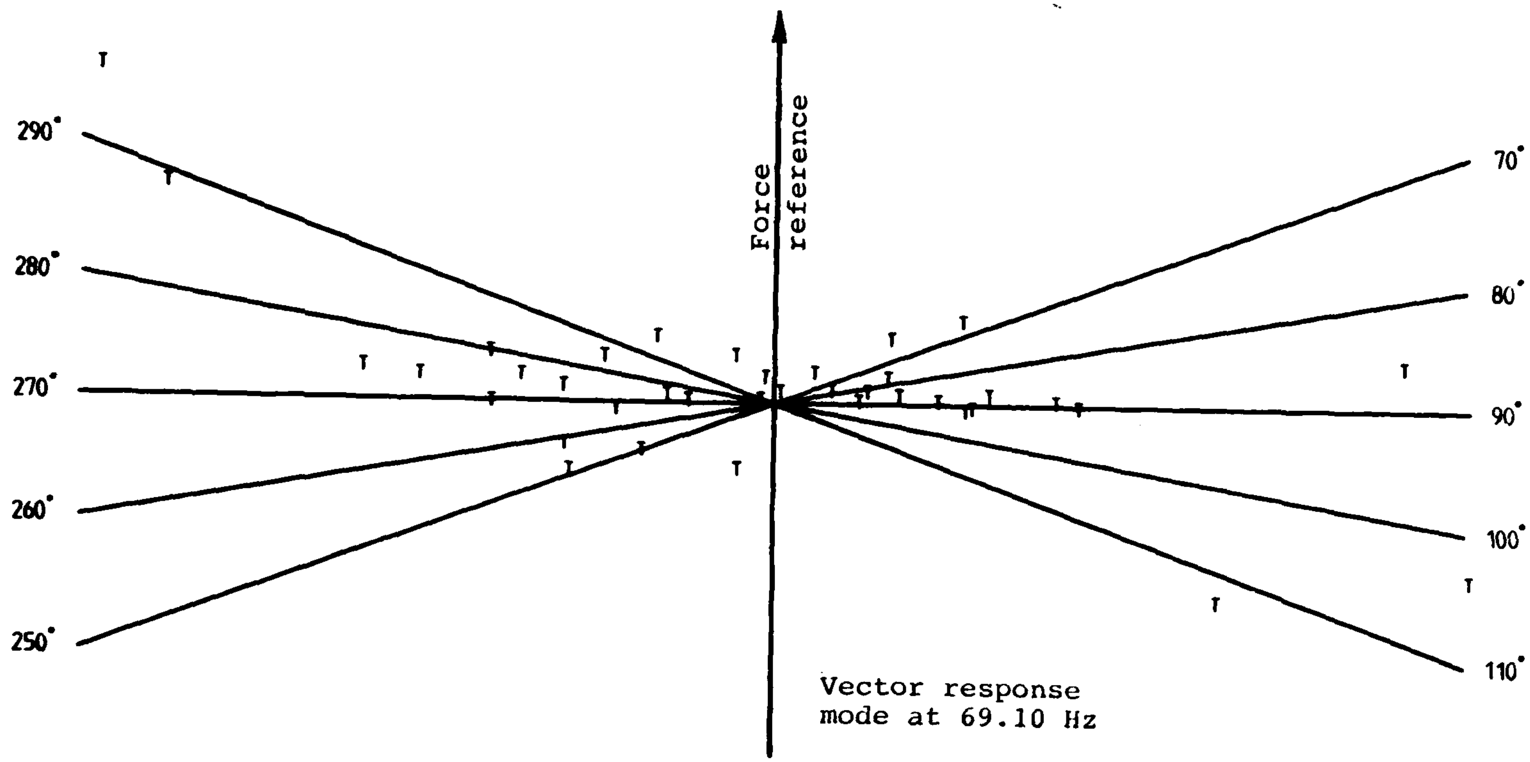
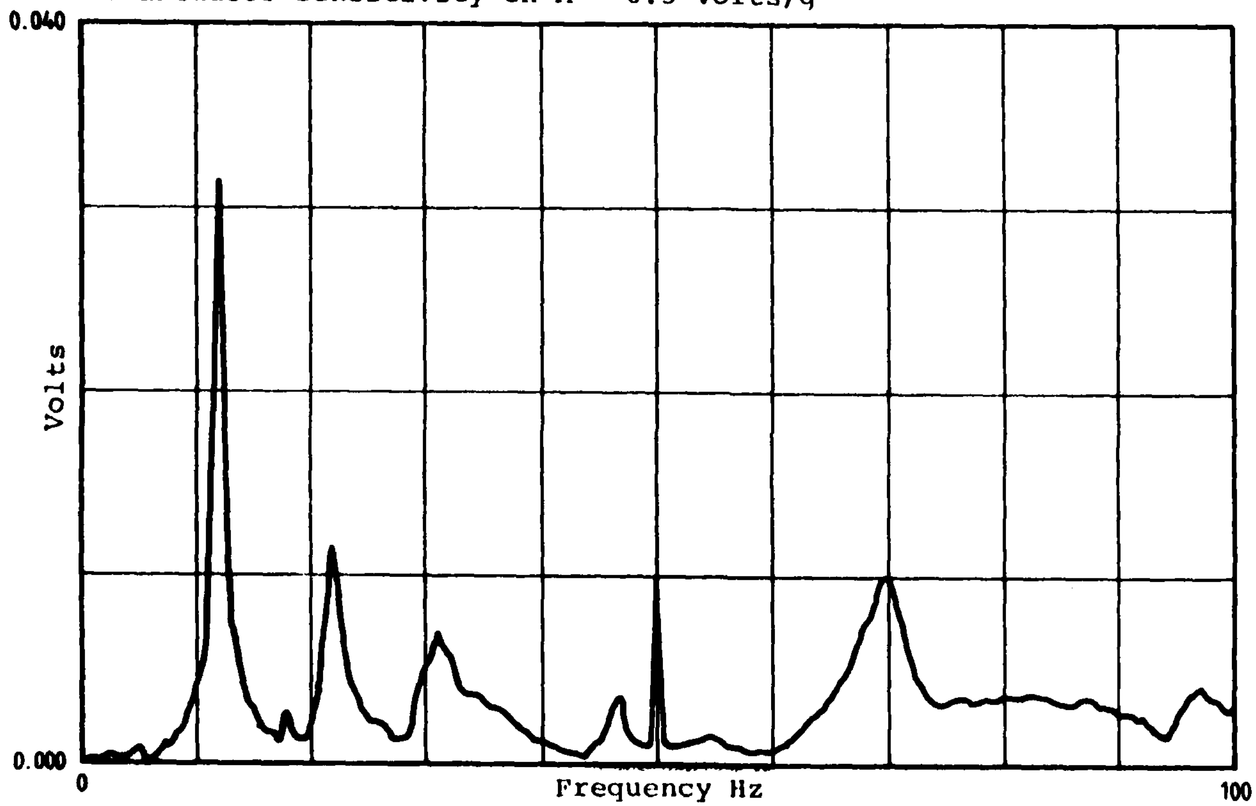


FIG. 6(b) VECTOR RESPONSE OF MODE AT 69.1 Hz

Instantaneous spectrum

Transform size - 1024. No.of samples - 1.
Transducer sensitivity CH A = 0.5 volts/g



CT4 T/P impulse .. with vibrators attached

FIG. 7 RESPONSE AT TAILPLANE LEADING EDGE TO IMPULSE

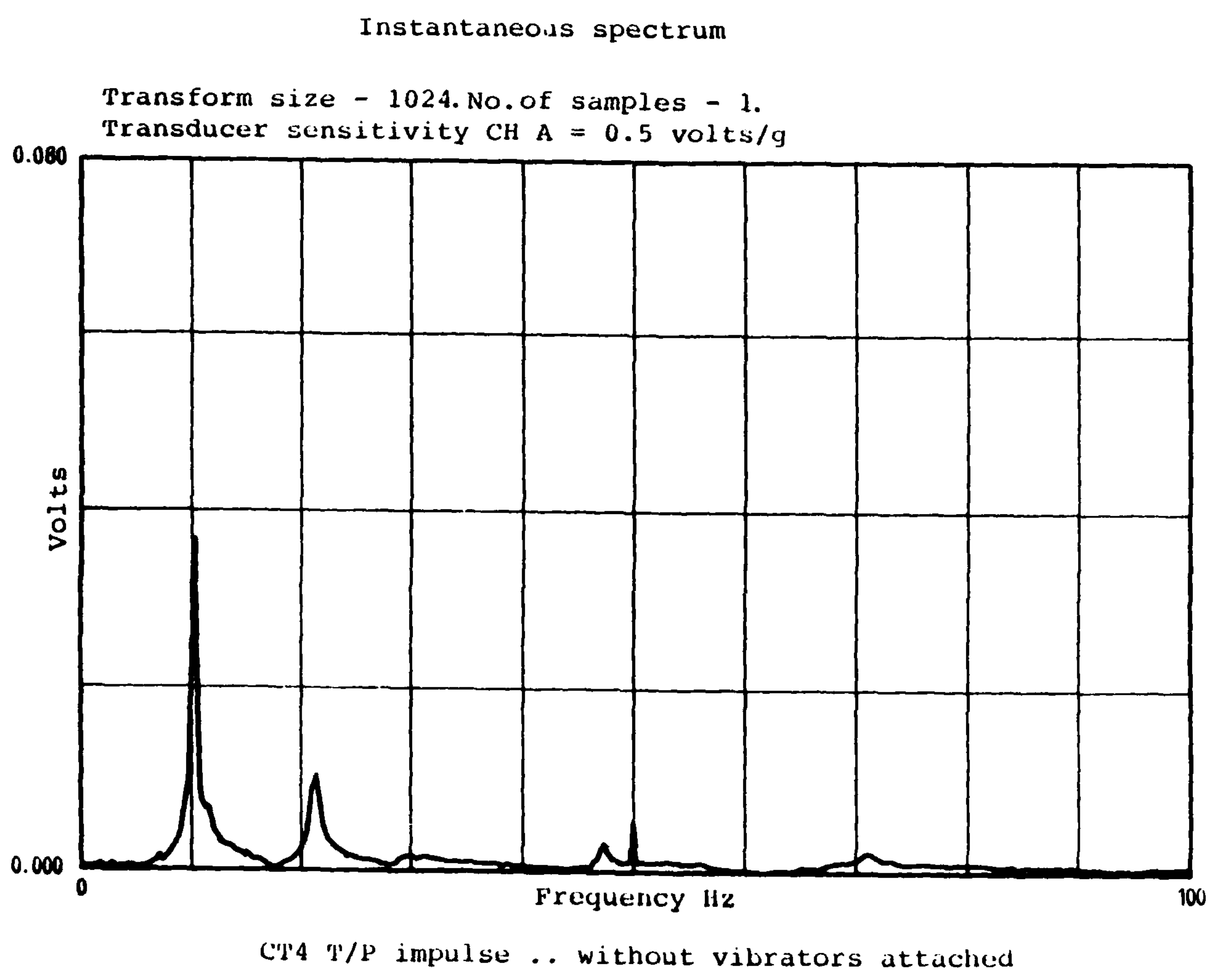


FIG. 8 RESPONSE AT TAILPLANE LEADING EDGE TO IMPULSE

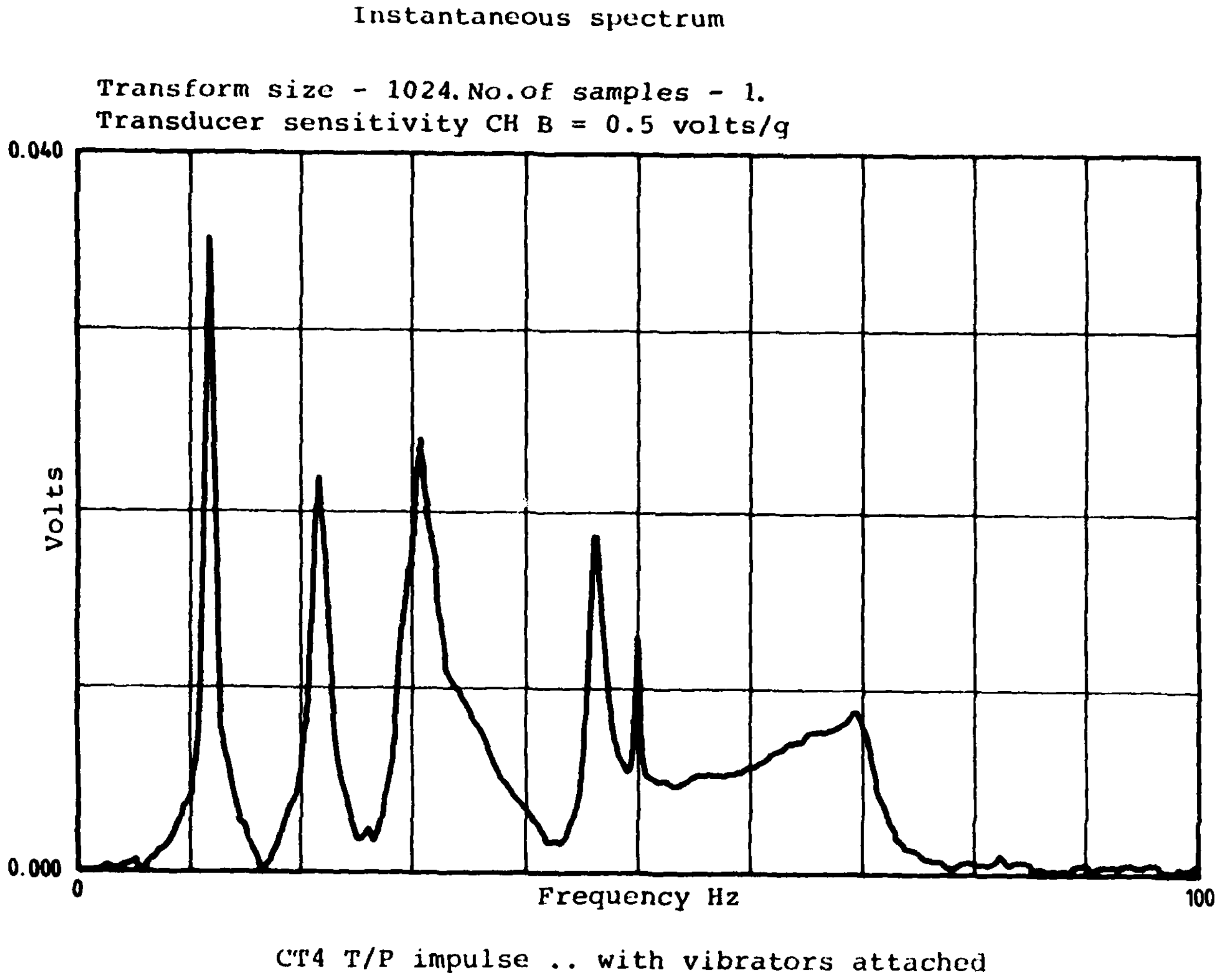


FIG. 9 RESPONSE AT ELEVATOR TRAILING EDGE TO IMPULSE

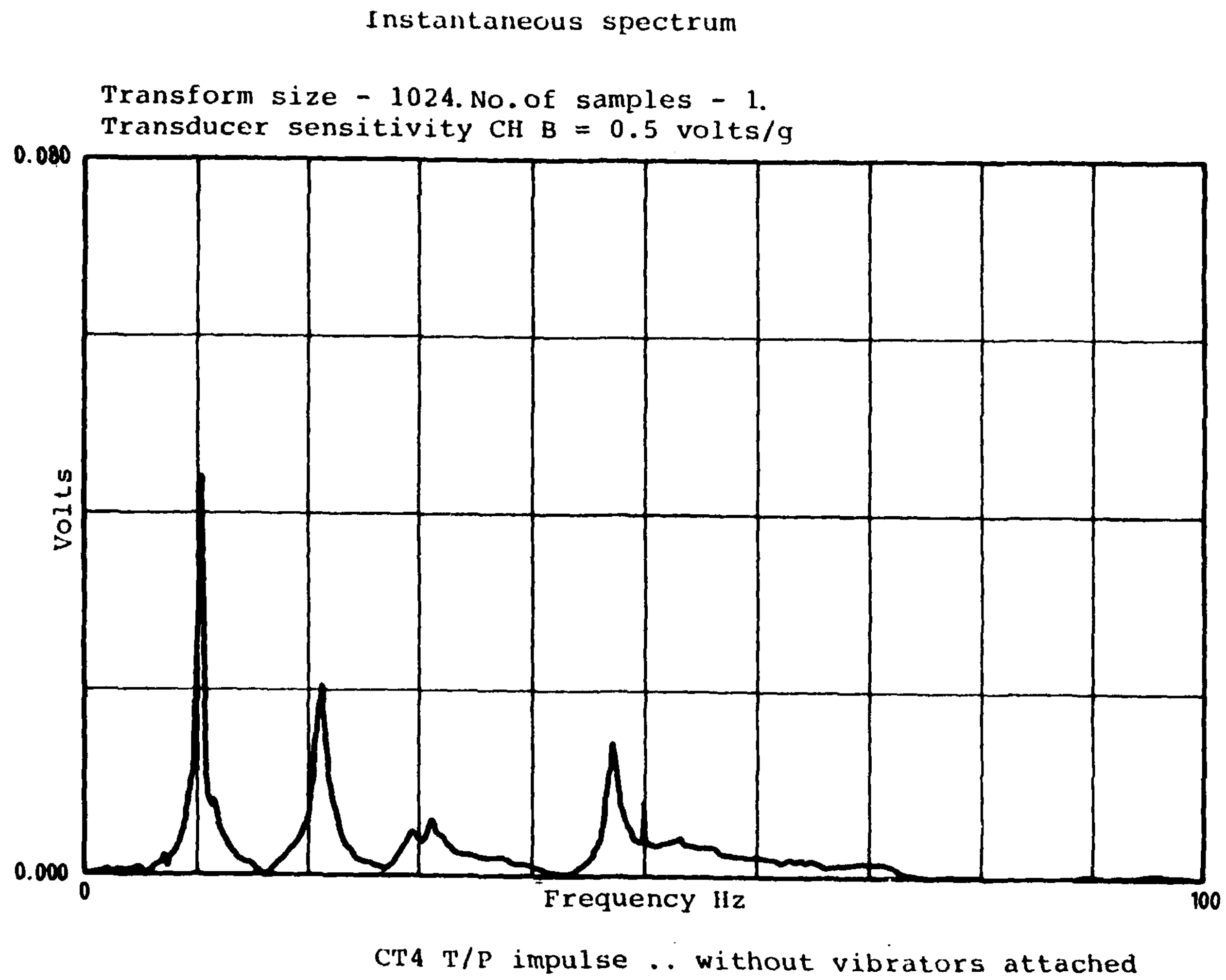


FIG. 10 RESPONSE AT ELEVATOR TRAILING EDGE TO IMPULSE

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Resonant frequency
Airfoils
Elevators (control surfaces)
Horizontal tail surfaces
CT4A Airtrainer

15. COSATI Group

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16. Abstract

A resonance test has been carried out on the tail section of a CT4 aircraft. Natural modes and frequencies of the tailplane were measured and these results are presented.

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